PILOT PROJECT

EVALUATION OF THE EASTERN SPRUCE BUDWORM PREDICTION SCHEME AND A TREE VIGOR ASSESSMENT METHOD FOR THE LAKE STATES[1/]

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St. Paul Field Office

1/ The prediction scheme is part of a nationwide evaluation of the western budworm egg mass survey developed by MAG.

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INTRODUCTION

The spruce budworm is the most important insect pest threatening the three million acres of commercial spruce-fir type in the Lake States. In recent studies in Minnesota, after five years of heavy defoliation, 67% of the basal area of fir and 42% of the basal area of spruce were lost. Survey information from the Superior National Forest in 1977 show over 750,000 acres of dead balsam fir. Similar mortality is occurring in upper Michigan where over 900,000 acres were defoliated in 1977. This pattern of the budworm damage and tree mortality is not compatible with the needs of todays society. Balsam fir is becoming extremely important now because it supplies the major portion of the softwood portion of our pulp production in the Lake States. It is also playing an increasing role in the construction grade of lumber. The land manager must know where the outbreaks are going to occur and how to schedule harvesting and/or spraying operations for damaged stands to administer the resource effectively. Because of these needs, we propose to evaluate a budworm population prediction scheme and tree vigor assessment method this year.

Presently there are several different survey methods that are used in the United States for sampling spruce budworm egg masses and predicting probable defoliation levels in balsam fir stands. The variety of survey methods makes defoliation prediction comparisons difficult. Our cooperators are desirous of having a uniform and more accurate sampling and prediction system so all land managers have the same basis for management decision. This pilot project is part of a nationwide evaluation of the western budworm egg mass survey for its applicability in different regions. The work plan and data analysis has been coordinated in the different regions by our Methods Application Group in Davis, CA.

Another part of the project is to evaluate a tree vigor system developed in Canada for rating vigor condition of sample tree and stand during a spruce budworm outbreak. This information is valuable to the land manager for scheduling harvest and/or initiating a spray program.

A successful development of correlation between egg mass populations and consequent defoliation may result in reduction of extensive and expensive egg mass sampling that we are currently doing. The data from this survey together with the tree vigor portion of the pilot test should provide accurate information on spruce budworm impact on the fir resource supply.

OBJECTIVE

The objective of this pilot test is to evaluate the western spruce budworm egg mass/defoliation survey procedures and the Canadian tree vigor assessment method for applicability to Lake States balsam fir stands.

METHODS

Egg mass/defoliation survey

1. Area Selection (See Appendix 1 for detailed instructions and forms.)

   Three Ranger districts on each of the following National Forests will be designated as Management Units for sample egg mass and defoliation surveys. The Forests are the Superior, Ottawa, Hiawatha, and Chequamegon.

   Within each selected district, five fir stands will be used. Each will be a minimum of 50 acres; each with light to moderate past defoliation (0-50%). Within each stand, five plots will be permanently marked for egg mass and defoliation sampling through the 1980 season.
   4 Forests X 3 Ranger districts X 5 stands X 5 plots = 300 plots.

   A fir stand is a stand of trees being managed for balsam fir; the fir component is usually 25 percent or more.

2. Plots

   Each plot will consist of 3 codominant or dominant crown balsam-fir. Each selected tree will be numbered for future sampling.

3. Sampling Unit

   a. The egg mass sample unit will be a 27 inch branch taken from the midcrown. Two branches will be cut from each sample tree for a total of six branches.

   b. Defoliation sample unit will be four branches from each of the three sample trees at each plot.

4. Data (attached field form)

a. Egg mass survey

1. Measure length and width of foliated portion of sample branch to nearest centimeter and record for computation of square meters of foliage.

2. Cut foliated portion of sample branch into short lengths and lay on grid paper to count square centimeters of foliage.

3. Examine all foliage and record egg masses as hatched, or unhatched.

4. Save one egg mass on the needle from one branch of each sample tree to obtain the average number of eggs per mass. Each egg mass held for measurement to estimate the number of eggs will also be used to estimate the percent of eggs hatched.

5. Egg mass populations will be recorded separately for the terminal 15 inches of each branch sample as well as for the entire branch (70 cm). This will allow comparison of the efficacy of the western budworm sample branch size with the sample size generally used for eastern spruce budworm egg mass sampling.

b. Defoliation

Cut 25 current branch tips from each of the four sample mid-crown branches per tree. Estimate the degree of defoliation on each tip from each branch. Record as total of class ratings for each branch. Divide by four to obtain average level defoliation for each tree. A count of live and dead terminal bud clusters will be recorded for each of the 25 current growth tips used for determining current season defoliation. Loss of the terminal buds indicated reduced branch vigor and foliar area for larval feeding the following season.

Defoliation Classes	% Defoliation
1	0-25
2	26-50
3	51-75
4	75 +

Tree vigor survey (See Appendix II for Figures.)

The condition of the bud clusters on the main terminal and two adjacent laterial shoots are recorded as live, dead (missing) together with the defoliation (in approximately 10% increments) for each sample branch used for egg mass counts. These data will be recorded as indicated in the attached form and defoliation classification (Figure 1 and 2). Each area and plot are the same as those used for the western budworm egg mass/defoliation correlation survey.

DATA ANALYSIS

Egg mass/defoliation

Analysis of data will be performed by the Methods Application Group in Davis, CA, according to the problem used to evaluate the western budworm egg mass and defoliation data. A synopsis of the instructions and analysis is found below.

Data gathered by the working group will be combined and analyzed through facilities at the Fort Collins Computer Center (FCCC). Regression models for egg mass density-defoliation will be generated for each entomological unit sampled and for each Forest. Models will be evaluated to determined whether or not the same model(s) will predict defoliation within regions or west-wide.

Regional personnel will be responsible for editing, coding, and punching data prior to entering into the FCCC system. Summary tables will be produced for decision-making purposes by regional personnel as soon as their data is entered into the system. Detailed instructions for coding and editing of data, with examples of expected summary tables, have been provided to regional personnel (See Appendix).

The egg mass/defoliation relationships will be used to improve existing prediction models. The models under consideration are linear, quadratic and other linearized forms by transformations. The independent variable (X) is egg-mass and the dependent variable (Y) is defoliation.

In standard linear regression, three basic assumptions are made about the relationship of Y and X:

1. For each selected X there is a normal distribution of Y from which the sample value of Y is drawn at random.

2. The population of values of Y corresponding to a selected X has a mean μ that lies on a straight line. $\mu + \beta (x - x) + \alpha = \beta X$.

3. In each population the standard deviation of Y about its mean, $\alpha + \beta X$.

The mathamatical model is specified by $Y = \alpha + \beta X + \varepsilon$ where ε is the random error term (Snedecor and Cochran, 1967).

Two considerations need to be addressed with the applications of the egg mass and defoliation variables:

1. Independent samples are drawn from which the X and Y values are determined.

2. The values of each X and Y are cluster level means based on six and 12 samples, respectively. A sub-sampling scheme is used by averaging branches to trees and the three trees to the cluster.

The first consideration causes no great concern since, if we draw a second sample, the values of X could in part be different, but the corresponding Y values will still meet the three basic assumptions.

The second situation poses a little more serious problem. The values for both the X and Y variables contain a sampling error component due to sub-sampling branches and trees A basic assumption in linear regression is the X is fixed and free of measurement and/or sampling error. In many applications this is not reasonable and is often violated. The biases are thought to be negligible if the sampling errors do not exceed 10 percent. Usually this occurs when the sample size for each observation is relatively large and/or the data is clustered such that the variation is small.

The use of regression analysis must be done keeping in mind the basic assumptions, and those not being satisfied should be evaluated for the degree of bias. During the course of the egg mass defoliation study, the effects of bias in regression estimators will be examined.

Tree vigor

1. Branch vitality index (BVI)

$$BVI = \frac{(3)\ (BA) + D}{4}$$

where BA = % buds absent
D = % defoliation

2. Tree vitality index (TVI)

$$TVI - \frac{BVI}{nb}$$

BVI - Branch vitality index
nb = number of branches

3. Stand vitality index (SVI)

$$SVI = \frac{TVI}{nt}$$

TVI - Tree vitality index

nt - number of sample trees.

A more detailed view of the data analysis can be obtained from the attached publication by Dorais and Hardy, 1976.

APPENDIX I

APPENDIX I

WESTERN SPRUCE BUDWORM EGG MASS - DEFOLIATION SURVEYS

Instructions for Coding and Editing Data

I. Coding Identification: Egg Mass Survey Data Form; Defoliation Survey Data Form.

Year - (1-2) Enter last 2 digits of current year.

Region - (3-4) Enter 2 digit number to indicate Region.

Forest - (5-7) Enter standard 3 digit number for specific National Forest.

Host - (8-9) Enter 01 for Douglas-fir. (P. menziesii).
02 for Grand fir. (A. grandis).
03 for White fir. (A. concolor).
04 for Subalpine fir (A. lasiocarpa).
09 for Balsam fir (A. balsamea).

Unit - (10-11) Enter 2 digit number to indicate entomologi unit (block) sampled.

Cluster - (12-13) Enter 2 digit number to indicate cluster (plot) sampled.

Survey Type - (14) Enter 01 for Egg Mass Survey.
Enter 02 for Defoliation Survey.

Option 1 - For additional data as required by Regions.
Option 2
Option 3 - (Defoliation Survey Data form only)

Coding Data

Egg Mass Survey Data Form:

Tree - (21) Enter 1 digit number for tree in cluster.

Branch Length - (22-24) (51-53) Enter 3 digit number for length in centimeters of sample branch.

Branch Width - (25-27) (54-56) Enter 3 digit number for width ir centimeters of sample branch.

Branch Area - (28-32) (57-61) Enter 5 digit number for area in square meters of sample branch.

New Egg Masses

Number - (33-35) (62-64) Enter 3 digit number for total curre year egg masses per branch.

Number of Rows - (36-38) (65-67) Enter 3 digit number for number of rows of eggs in one egg mass per branch.

Row Length - (39-41) (68-70) Enter 3 digit number for length in millimeters of one egg mass per banch.

Unhatched Eggs - (42) (72) Enter 1 digit code for estimate of percent unhatched eggs in one egg mass per branch, either parasitized or non-viable.

Code	Percent Unhatched
1	0-25%
2	25-50%
3	50-75%
4	75-100%

Optional Use - (43-50) (72-79) For additional data as required by Regions.

Defoliation Survey Data Form:

Tree - (21) (34) (47) Enter 1 digit number for tree in cluster.

Defoliation - (22-24) (25-27) (28-30) (31-33) (35-37) (38-40) (41-43) (44-46) (48-50) (51-53) (54-56) (57-59) Enter 3 digit number for total cumulative defoliation rating per branch.

Optional Use - (60-80) For additional data as required by Regions.

II. Editing Data Forms

All field-collected data will be entered on both forms in pencil.

All laboratory data (i.e., egg mass numbers, length, and width) will be entered on forms in blue pencil.

All field and laboratory data must be edited for accuracy and completeness. Corrections and verifications (i.e., atypical data) will be made in red pencil on data forms.

A raw data listing will be generated from the computer to be used for a final check on the data. Changes can be made in the raw data at this time prior to summary.

Egg Mass Survey Data Form: Branch length and width are measured in the field; branch area column must be completed in the laboratory by the grid method.

III. Output Specifications

Level of output - For each entomological unit sampled, a Table 1 and 2 will be generated showing cluster (plot) averages and standard errors. Correlations and prediction models will be produced, as in Table 3.

WESTERN SPRUCE BUDWORM EGG MASS SURVEY DATA FORM

Year 77 (1-2) T. ___ R. ___ S. ___ Date ___ Crew Name: ___

Region 09 (3-4) Forest Sup (5) Host Douglas Fir (8-9) Unit R1 (10-11) Clu

Survey Type 01 (14) Opt. 1 Sample Compute (15-) Opt. 2 ___ (20)

Tree	Branch	* Length (cm)	* Width (cm)	** Area (M^2)	NEW EGG MASSES Number	No. 1/ Rows	Row 1/ Length (mm)	Un-1/ hatched Eggs	O
(21)		(22-24)	(25-27)	(28-32)	(33-35)	(36-38)	(39-41)	(42)	(
1	1	70	60	0.21	4	2	6		1
	2	(51-53) 70	(54-56) 70	(57-61) 0.245	(62-64) 3	(65-67) 2	(68-70) 5	(71)	1
(21)		(22-24)	(25-27)	(28-32)	(33-35)	(36-38)	(39-41)	(42)	(
2	1	70	58	0.203	0	—	—		
	2	(51-53) 70	(54-56) 82	(57-61) 0.287	(62-64) 0	(65-67) —	(68-70) —	(71)	(
(21)		(22-24)	(25-27)	(28-32)	(33-35)	(36-38)	(39-41)	(42)	(
3	1	70	90	0.315	8	3	10		1
	2	(51-53) 70	(54-56) 72	(57-61) 0.252	(62-64) 1	(65-67) 2	(68-70) 9	(71)	(
				1.512	17				

Cluster Average

Egg Mass/m^2: 10.11

Egg mass/m^2 = $\left[\sum_{\text{Tree}}^{3} \sum_{\text{Branch}}^{2} \left(\frac{\text{egg mass/bra}}{m^2/\text{branch}}\right)\right.$

$\frac{\Sigma \text{ Tree egg mass}}{\text{Tree}}$ 68.65 / 6 5

1/ Data to be taken on 1 egg mass/branch

* Length; width - completed in field by branch measurement.

** Area - completed in lab by grid method.

$M^2 = \frac{\text{Length} \times \text{width}}{2} \div 10{,}000$

$T_1 B_1 = M^2 = \frac{70 \times 60}{2} \div 10000 = \frac{4200}{2} \div 10{,}000 = 0.21$

Figure 1. Data form for egg mass surveys of the western spruce bud

Year ____ (1-2) T. ____ R. ____ S. ____ Date ____ Crew Name: ____

Region ____ (3-4) Forest ____ (5-7) Host ll/ (8-9) Unit ____ (10-11) Cluster ____ (

Survey Type 7 (14) Opt. 1 Abie (15-17) Opt. 2 ____ ( ) Opt. 3 ____ (20)

Tree	Branch	Defoliation 1/	Tree Average 2/	Comments
(21) 1	1	(22-24) 44	186/4 = 46.5	
	2	(25-27) 50		
	3	(28-30) 64		
	4	(31-33) 28		
(34) 2	1	(35-37) 24	136/4 = 34.0	
	2	(38-40) 38		
	3	(41-43) 32		
	4	(44-46) 40		
(47) 3	1	(48-50) 80	242/4 = 60.5	—
	2	(51-53) 66		
	3	(54-56) 54		
	4	(57-59) 42		

Total: 141

1/ Defoliation = Total of ratings from 25 shoots per branch.

2/ Tree Average = $\frac{\Sigma \text{ Defoliation}}{4}$

Average percent defoliation (

$= \frac{\Sigma \text{ tree average}}{3} - 12.5 =$ ____

$\frac{141.0}{3} - 12.5 = 34.5$

Figure 2. Field data form for defoliation surveys of the western spruce

WESTERN SPRUCE BUDWORM EGG MASS SURVEY DATA FORM

ar _____ (1-2) T. ___ R. _____ S. _____ Date _____ Crew Name: _____

gion _____ (3 - 4) Forest _____ (5 - 7) Host _____ (8 - 9) Unit _____ (10 - 11) Cluster

rvey Type _____ (14) Opt. 1 _____ (15 -) Opt. 2 _____ (20)

ee	Branch	* Length (cm)	* Width (cm)	** Area (M^2)	NEW EGG MASSES Number	No. [1]/ Rows	Row [1]/ Length (mm)	Un-[1]/ hatched Eggs	Optio
1)		(22-24)	(25-27)	(28-32)	(33 -35)	(36-38)	(39-41)	(42)	(43-
1	1								
	2	(51-53)	(54-56)	(57-61)	(62 - 64)	(65-67)	(68-70)	(71)	(72-
1)		(22-24)	(25-27)	(28-32)	(33 - 35)	(36-38)	(39-41)	(42)	(43-
	1								
	2	(51-53)	(54-56)	(57-61)	(62- 64)	(65-67)	(68-70)	(71)	(72-
1)		(22-24)	(25-27)	(28-32)	(33- 35)	(36-38)	(39-41)	(42)	(43-
	1								
	2	(51-53)	(54-56)	(57-61)	(62- 64)	(65-67)	(68-70)	(71)	(72-

luster Average

g Mass/m^2: _____

Egg mass/m^2 = $\left[\sum_{\text{Tree}}^{3} \sum_{\text{Branch}}^{2} \left(\frac{\text{egg mass/branch}}{m^2/\text{branch}} \right) \right.$

Data to be taken on 1 egg mass/branch

Length, width - completed in field by branch measurement.

Area - completed in lab by grid method.

Figure 1. Data form for egg mass surveys of the western spruce budworm.

Year _____

WESTERN SPRUCE BUDWORM DEFOLIATION SURVEY DATA FORM

Region _____ Forest _____ Host _____ Unit _____ Cluster _____

Survey Type _____ Opt.1 _____ Opt.2 _____ Opt.3 _____

Tree	Branch	Defoliation 1/	Tree Avg. 2/	Comments
1	1			
	2			
	3			
	4			
2	1			
	2			
	3			
	4			
3	1			
	2			
	3			
	4			

Total: _____

1/ Defoliation = Total of ratings from 25 shoots per branch.

2/ Tree Average = $\frac{\Sigma \text{ Defoliation}}{4}$

Average per cent defoliation (clus
= $\frac{\Sigma \text{ tree avg.}}{3}$ -12.5 = _____

APPENDIX II

DEFOLIATION SCHEMATIC

SPRUCE BUDWORM PILOT CONTROL PROJECT

Block _____ Tree No. _____ Chemical _____ Crew _____

Branch

_____

Prespray Date

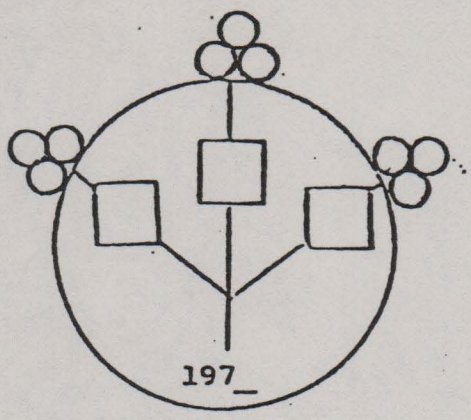
_____

Percent Buds

_____

$\bar{X}$ Fettes Class

197_ _____



PRESPRAY

Postspray Date

_____

Percent Buds

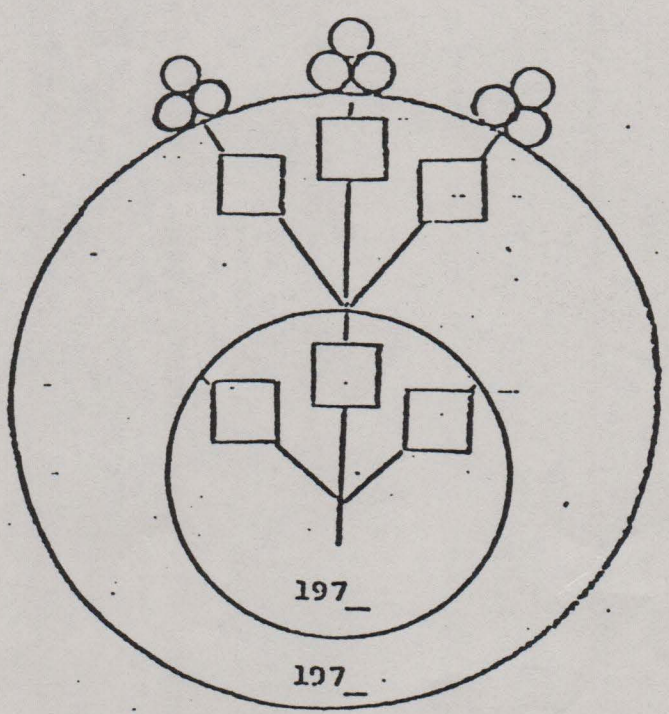
_____

$\bar{X}$ Fettes Class

197_ _____

$\bar{X}$ Fettes Class

197_ _____



POSTSPRAY

FIGURE 2.

CURRENT YEAR DEFOLIATION

Spruce Budworm Pilot Control Project

Fettes Classification
and
Percent Defoliation

0

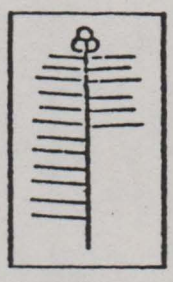
0

1

1-10

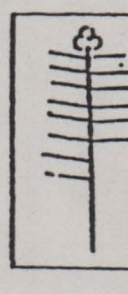
2

10-20



3

20-30



4

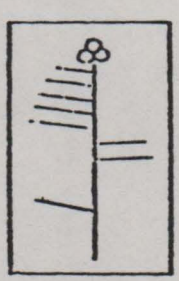
30-40

5

40-50

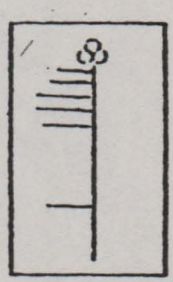
6

50-60



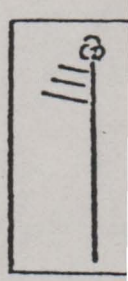
7

60-70



8

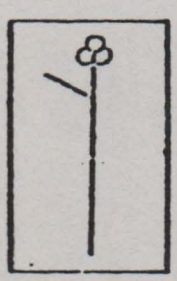
70-80



9

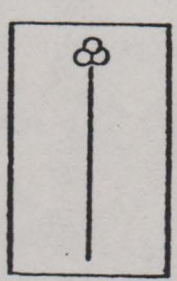
80-9

10



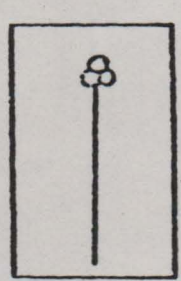
90-100

11



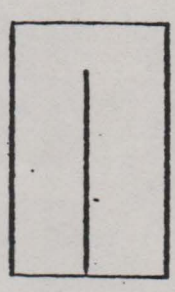
100

11+



100
Live bud.
Old bud
dead.

12



100+
Old bud dead.
No new bud.

APPENDIX III

ESTIMATED COST

These estimates do not include salaries or per diem for permanent personnel.

*Salaries	
6 Summer students for 50 days (3 GS-5 & 3 GS-4)	$12,600.00
Per Diem	
6 Summer students for 50 days	10,500.00
Travel for field crews	
3 GSA vehicles @ $57./month and .07 cents/mile.	1,260.00
Mis..field equipment, data analysis and report	1,250.00
Total	$25,610.00

* GS-4 @ $4.28/hr + 15% overhead = $5.00/hour
* GS-5 @ $4.79/hr + 15% overhead = $5.50/hour

USDA-FOREST SERVICE

PROJECT WORK PLAN

1. UNIT: NA, FIDM

SUB-UNIT: St. Paul Field Office

PROJECT NO.: | FISCAL YEAR:

2. MANPOWER (List by Name)	DAYS	DAILY RATE	PLANNED COSTS TO BE FINANCED	PLANNED COSTS CONTRIBUTED
PROJECT LEADER OR FOREMAN Arthur R. Hastings				
3 GS-5 - SS Salary	50		6,600	
3 GS-4 - SS Salary	50		6,000	
5 - SS Per diem	50		10,500	
PER DIEM, TRAVEL AND MEALS			23,100	

EQUIPMENT (F.S. and Rental)	MONTHS F.O.R.	HOURS OR MILES	F.O.R. OR USE RATE		
3 GSA vehicles	2.5		56/m	420	
		2000	41/m	840	
				1,260	

MATERIALS AND SUPPLIES	QUANTITY TO BUY	QUANTITY ON HAND	UNIT PRICE		
Field Supplies				500	
Data Analysis				500	
Interim Report				250	
CONTRACT				1,250	
TOTAL PLANNED COST	FINANCED + CONTRIBUTED			25,610	

PROJECT NAME, LOCATION, DESCRIPTION, ACCOMPLISHMENT TARGET, AND MANAGEMENT PLAN.

Western spruce budworm egg mass/defoliation correlation for the Lake States Area.

Survey evaluation pilot test and tree vigor (Fettes survey) survey.

Superior, Ottawa, and Hiawatha National Forests

Continuing FY 77- FY 79

BEGIN WORK: 5/78 | COMPLETE WORK: 9/79

SPECIAL SKILLS NEEDED	DAYS	WHEN

4. PROPOSED BY: A. R. Hastings | DATE: 4/3

STAFF REVIEW BY:

APPROVED BY:

FUNDS ALLOCATED BY:

3. FINANCE AND ACCOUNTING DATA

APPROPRIATION	STAT CODE	ACCOUNT OR ACTIVITY	FUNCTION MAJOR	FUNCTION SUB	SUB-UNIT	DOLLARS PLANNED AND ALLOCATED
TOTAL ALLOCATED						

5. ACCOMPLISHMENT RECORD | DATE | INITIAL

1900-4 (11/77)